

# PATENT SPECIFICATION

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DRAWINGS ATTACHED

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## (54) IMPROVEMENTS IN DEVICES FOR PURIFYING INTERNAL-COMBUSTION ENGINE EXHAUST GASES CONTAINING SOLID COMPONENTS

(71) We, AUTOMOBILES M. BERLIET, a French Body Corporate of 30, quai Claude Bernard, Lyon (Rhône) France, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention is concerned with an improved device for purifying exhaust gases of internal combustion engines which contain solid components. Certain engines, such as Diesel engines, release exhaust gases containing, in addition to very small quantities of gaseous combustion products, such as carbon monoxides, nitrogen oxides, aldehydes and organic acids, components still in a solid state of which the principal one is soot, especially when considerable fuel quantities are injected. This soot, which results from the cracking of the fuel hydrocarbons, consists of very fine particles and has a very large specific surface area of the order of 200 to 300 square meters per grams (60,000 to 90,000 sq.ft. per oz), so that it can adsorb aromatic polycondensates and other organic compounds, such as 3,4-benzopyrene, of which the carcinogenic character is well known.

As a result, the problem of cleaning or purifying exhaust gases notably of Diesel engines consists primarily in eliminating soot therefrom. More particularly, this problem consists in eliminating relatively small quantities of extremely small solid particles of diameter of the order of 0.1 to 1  $\mu$ , amounting to 0.1 to 3 grams per cubic meter of exhaust gas, from a stream of hot gases the output of which can vary at any time and may even attain a hundred cu.ft. per minute or more.

Hitherto known exhaust filter devices are objectionable mainly in that they are liable to clogging and must therefore be replaced at frequent intervals.

The Applicants already proposed in a former patent application No. 44.188/65 of October 19, 1965, (Serial No. 1,128,661) a purifying device of the catalytic type comprising a filter element of refractory fibrous material impregnated with a catalyst serving the purpose of promoting the ignition of any combustible gaseous products contained in the exhaust gases while ensuring at the same time the combustion of the retained solid components such as soot.

It is an object of the present invention to provide a purifying device for eliminating the visible black smoke from exhaust gases, excluding the gaseous products such as irritating gases and unpleasant smells, this device being further characterised in that its cost is considerably lower than that of catalytic-type cleaners (since the reduction in the cost of the filter cartridge may be in the ratio of as much as 10 to 1), while having a greater efficiency than the aforesaid exhaust filters, but without the inconveniences thereof.

According to the invention we provide a device for purifying exhaust gases of an internal combustion engine, the device comprising a filter element of a refractory fibrous material capable of retaining solid particles entrained in exhaust gases passed therethrough, where in the refractory fibrous material comprises alumina-silica wool, the device also including means for attaching the device sufficient close to an internal combustion engine for the temperature of the exhaust gases to cause combustion of the solid particles such as soot retained on the alumina-silica wool when the engine is running at full power. The invention also includes the said device when fitted to an internal combustion engine.

According to a further feature of the invention, we provide a method of purifying exhaust gases of an internal combustion engine, comprising passing the exhaust gases

through a filter element of alumina-silica wool which is capable of retaining solid particles, the temperature of the exhaust gases being sufficiently high to cause combustion of the solid particles such as soot retained on the alumina-silica wool.

If the engine is operated rather frequently under full-load condition, the exhaust gases may be hot enough to ensure a constant or permanent combustion of the retained soot.

In this case, the combustion rate remains relatively low and is closely related to the exhaust gas temperature; a rapid combustion is actually obtained only when the temperature at the inlet end of the purifying device is about 600°C.

It was found that if under practical service conditions the engine is caused to operate at maximum speed and under full-load so as to raise the temperature to the above-given value, the purifying device itself can be thoroughly cleaned by rapidly burning the soot accumulated therein, within about ten minutes.

This high-speed engine operation may be accidental (i.e. due to the conditions of operation of the engine) or voluntary. In this last case a cleaning operation is also achieved.

It may be emphasized that the purifying device of this invention, intended primarily for eliminating visible black smokes from exhaust gases, provides a satisfactory solution to the important problem of air pollution which arises when town vehicles and more particularly town buses are equipped with Diesel engines.

Thus, more particularly, alumina-silica wool utilized in the form of fibres about one inch long and having a diameter of about 3  $\mu$ , is completely satisfactory. For instance, with a purifying device of the type described hereinafter a satisfactory result was obtained with the device arranged up to ten feet beyond the outlet of the engine exhaust manifold and connected thereto by a conventional exhaust pipe.

Moreover, the use of a purifying device incorporating a filter element it attended by a back-pressure in the engine exhaust, the back-pressure caused by the filter element according to this invention being easily limited to a relatively low value, for example well below 200 grams per sq.cm. (2.85 lb.p.sq.in.).

However, in case of prolonged engine operation under maximum speed and full-load conditions, the exhaust manifolds and the exhaust cleaner case are gradually heated, so that the exhaust gases are no more cooled as when running the engine intermittently at high speed and under full-load condition. Due to their higher temperature, the gases are much expanded and their volumetric flow-rate is high.

The back pressure across the filter element caused by this considerable flow rate exerts undue strain on the filter element, which may even destroy it if these extreme operating conditions are maintained during a relatively long time; besides, it may be noted that if purifying devices dimensioned to meet the severest operating conditions were used their cost would become excessive and their over-all dimensions would become prohibitive and prevent a convenient mounting on the vehicles to be equipped for the purpose contemplated.

This invention further provides a solution to the problem set forth above by adding to the purifying device a safety valve so disposed and calibrated that it will allow the gas to by-pass the filter element when a predetermined exhaust pressure value is attained. This safety valve will thus constitute an efficient means for stopping dangerous back-pressure being generated, without causing on the other hand any disturbance in the normal operation of the purifying device.

The conditions necessary for opening this safety valve are seldom those corresponding to the maximum release of black smoke through the exhaust. Thus, for example, when the engine is strongly accelerated from the idling speed, the safety valve is not actuated and the filter will retain the whole of the smoke normally released under such circumstances.

The provision of this safety valve will extend to a considerable degree the useful life of the filters mounted on engines of relatively great cubic capacity equipping automotive vehicles.

Moreover, the back-pressure limitation resulting from the use of this safety valve is also useful in that it will prevent the engine power output from being curtailed to an appreciable degree at maximum speed.

The single figures of the attached drawing illustrates diagrammatically by way of example a typical form of embodiment of the device constituting the subject-matter of this invention. This figure is an axial longitudinal section taken along an exhaust gas purifying device equipped with a safety valve.

The device illustrated consists of a silencer 1 having an inlet pipe 2 and a gas outlet pipe 3. The inlet pipe 2 is rigid with end plate or cover 4 secured in a fluid-tight manner to the main body of the silencer 1 with the interposition of a gasket, the end plate or cover 4 being secured to a flange 5 on the main body 1 for example by means of bolts 6.

Within the body 1 and secured to the end plate 4 is a cylindrical hollow filter element consisting of two concentric cylindrical wire-mesh members 7 and 8, for example stain-

less-steel fine-mesh members. The annular space formed between these wire-mesh elements 7 and 8 is stuffed with filtering material 9 consisting of alumina-silica wool refractory fibres.

The two cylindrical wire-mesh stainless-steel members 7 and 8 are welded to a bottom plate 10 closing completely the central passage 11 for the gases as well as the annular space between these members. This bottom plate acts as a member for centering the filter element and engages the inner wall of the cylindrical body 1. Peripheral notches 12 are formed in the outer edge of this plate 10 to permit the passage of exhaust gases therethrough.

The complete device is surrounded by a heat-insulating sheath 13 for example of asbestos fabric, adapted to be protected in turn from shocks and stonethrows by a metal cover (not shown).

The aforesaid safety valve may be easily mounted so as to co-act with a discharge port 14 provided in the central portion of the bottom plate 10, i.e. within the filter element. This valve comprises a valve member 15 normally seated on the edge of port 14 and provided with a shank extending through the bottom of body 1 and engaging a bearing cup 16 urged towards the body 1 by a compression spring 17 isolated from the exhaust gases by being housed in a small case 18 secured to the bottom plate 10 closing the rear of the body 1. The spring 17 is adjustable by means of another bearing cup 19 associated with an adjustment screw 20.

It is clear that when this valve is opened by the gas pressure, i.e. when the latter exceeds a predetermined value, the inlet and outlet pipes 2, and 3 of the device communicate directly with each other, thus allowing a direct exhaust of the gases which by-pass the filter element as long as the over-pressure prevails.

Of course, any other suitable valve type may be used for the same function without departing from the scope of the invention.

#### WHAT WE CLAIM IS:—

1. A device for purifying exhaust gases of an internal combustion engine, the device

comprising a filter element of a refractory fibrous material capable of retaining solid particles entrained in exhaust gases passed therethrough, wherein the refractory fibrous material comprises alumina-silica wool, the device also including means for attaching the device sufficiently close to an internal combustion engine for the temperature of the exhaust gases to cause the combustion of the solid particles such as soot retained on the alumina-silica wool when the engine is running at full power.

2. A device according to claim 1, including a safety valve adapted to permit gases to by-pass the filter element when the exhaust gas pressure exceeds a predetermined value.

3. A device according to claim 2, comprising a silencer in which said filter element is in the form of a sleeve for receiving the exhaust gases at one end and internally, said element forming with the silencer body an annular space for the flow of gases having passed through said sleeve, said safety valve being disposed at the opposite end of said sleeve and adapted to open into a chamber in which the gases having passed through said sleeve are collected.

4. A device according to any preceding claim when fitted to an internal combustion engine.

5. A method of purifying exhaust gases of an internal combustion engine, comprising passing the exhaust gases through a filter element of alumina-silica wool which is capable of retaining solid particles, the temperature of the exhaust gases being sufficiently high to cause combustion of the solid particles such as soot retained on the alumina-silica wool.

6. A device substantially as described herein with reference to the accompanying drawing.

7. A method substantially as herein described with reference to the accompanying drawing.

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1 SHEET

COMPLETE SPECIFICATION

This drawing is a reproduction of the Original on a reduced scale.

